National Aeronautics and Space Administration

# NASA'S MOON TO MARS ARCHITECTURE

## A SUMMARY OF THE 2022 ARCHITECTURE CONCEPT REVIEW PROCESS AND RESULTS – APRIL 2023

# NASA'S MOON TO MARS ARCHITECTURE

## A SUMMARY OF THE 2022 ARCHITECTURE CONCEPT REVIEW PROCESS AND RESULTS

## TABLE OF CONTENTS



## KEY TERMS

The following terms are frequently used in the pages ahead.

### ARCHITECTURE

The high-level unifying structure that defines a system. It provides a set of rules, guidelines, and constraints that defines a cohesive and coherent structure consisting of constituent parts, relationships, and connections that establish how those parts fit and work together.

### CHARACTERISTICS

Features or activities of exploration mission implementation that are necessary to satisfy the Goals and Objectives.

### ELEMENT

A notional exploration system enabling a high-level functional allocation, e.g., crew transport, habitation, logistics delivery, etc.

### FUNCTION

Actions that an architecture would perform necessary to complete the desired Use Case.

### NEED

A statement that drives architecture capability, is necessary to satisfy the Moon to Mars Objectives, and identifies a problem to be solved, but is not the solution.

### SEGMENT

A portion of the architecture, identified by one or more notional missions or integrated Use Cases, illustrating the interaction, relationships, and connections of the sub-architectures through progressively increasing operational complexity and objective satisfaction.

### USE CASES

Operations that would be executed to produce the desired Needs and/or Characteristics.

# 1. INTRODUCTION

NASA is leading a global, peaceful endeavor for human-led exploration and scientific discovery in deep space. This is a summary of NASA's recent body of architectural planning that sets the stage for a new era of exploration at the Moon and Mars.

The term "architecture" evokes schematics and engineering processes, and while what we build is soundly based in systems engineering processes, we are casting a brighter light on *why* we develop each architectural component. We build rockets, crew spacecraft, rovers, habitats, and robots to make possible a new era of scientific research, inspire the next generation of explorers, and shape our national posture at the Moon and at Mars. Our success at these exciting destinations will bring even more distant human exploration into the realm of possibility.

The architecture is driven by a suite of Moon to Mars Objectives, which NASA developed and refined with contributions from U.S. industry, academia, international space agencies, and its own workforce. The architecture development process outlined here provides a high-level summary of the detailed Architecture Definition Document available at **www.nasa.gov/MoonToMarsArchitecture**.

These products have been established to foster transparency across NASA's Moon to Mars exploration approach and create opportunities for current and future partners to find their place as contributors to human exploration in deep space. The architecture will continue to evolve over the coming years, informed by continued analysis, feedback from U.S. industry and international partners, advances in technologies, and maturing objectives.

# 2. MOON TO MARS OBJECTIVES

go.nasa.gov/3zzSNhp

The Moon to Mars Objectives define NASA's human deep space exploration strategy. The objectives identify what NASA wants to accomplish with its partners at different destinations, setting the framework for architecture development. Throughout 2022, NASA developed the objectives, issued an open call for feedback, and conducted two workshops — one with U.S. industry and one with international space agencies — to refine them.

Through the workshops and thousands of comments from industry, academia, international space agencies, and NASA's workforce, the objectives were refined to serve as the starting point for architecture development. The objectives will continue to evolve as new knowledge and technological capabilities emerge and more stakeholders come to the table. You can read more about the Moon to Mars Objectives online **here** or use the QR code above.

NASA's exploration vision is anchored in providing value for humanity by answering why it is important to society. The pillars of science, national posture, and inspiration form the foundation of the agency's exploration plans. These pillars form the basis for this set of Moon to Mars Objectives.

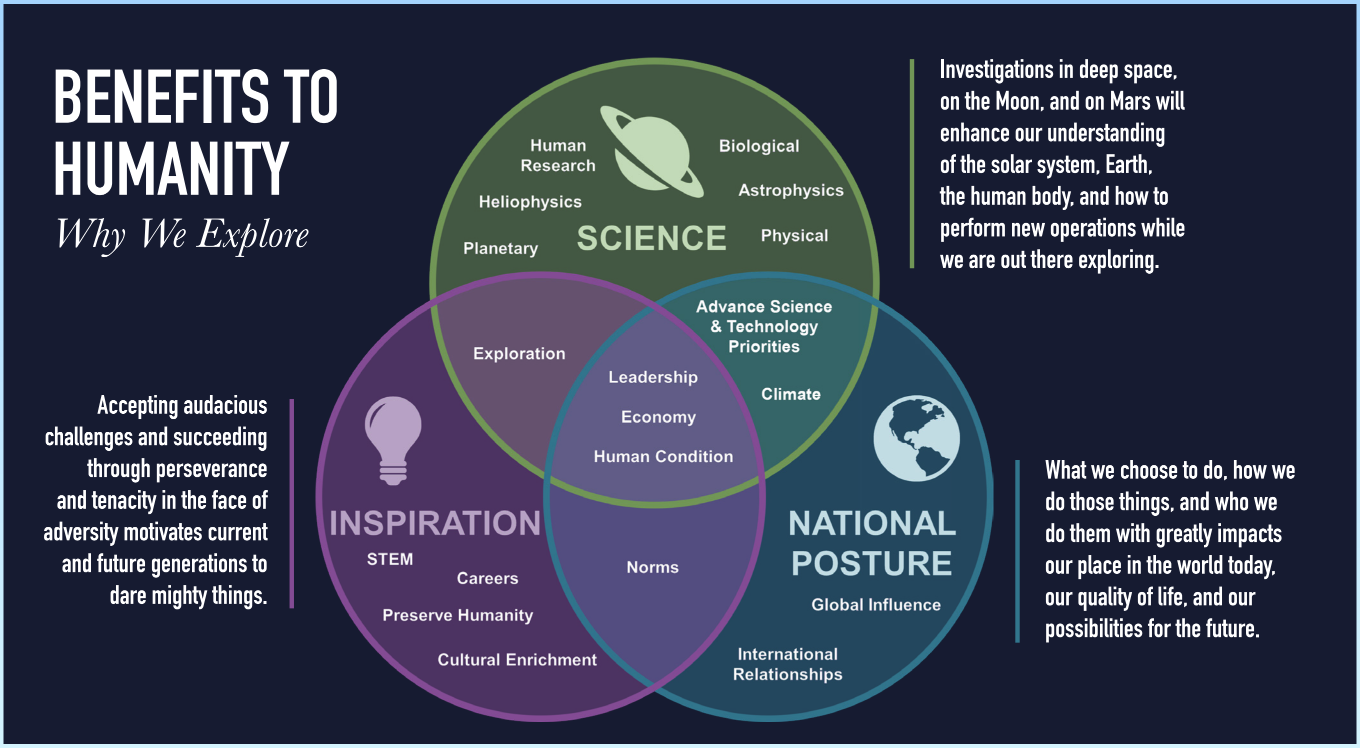



Figure 1: The three pillars of rationale for exploration: science, inspiration, and national posture.

The Moon to Mars Objectives guide the success of NASA's exploration strategy through the return of astronauts to the Moon, continued lunar science and exploration, and all the way to the first crewed landings on Mars, with the associated science and technology development required for success.

| GOAL | DESCRIPTION | NUMBER OF OBJECTIVES |
|---|---|---|
| **Lunar and Planetary Science** | Address high priority planetary science questions that are best accomplished by on-site human explorers on and around the Moon and Mars, aided by surface and orbiting robotic systems. | 4 |
| **Heliophysics** | Address high priority heliophysics science and space weather questions that are best accomplished using a combination of human explorers and robotic systems at the Moon, at Mars, and in deep space. | 4 |
| **Human and Biological Science** | Advance understanding of how biology responds to the environments of the Moon, Mars, and deep space to advance fundamental knowledge, support safe, productive human space missions and reduce risks for future exploration. | 3 |
| **Physics and Physical Science** | Address high priority physics and physical science questions that are best accomplished by using unique attributes of the lunar environment. | 2 |
| **Science Enabling** | Develop integrated human and robotic methods and advanced techniques that enable high-priority scientific questions to be addressed around and on the Moon and Mars. | 7 |
| **Applied Science** | Conduct science on the Moon, in cislunar space, and around and on Mars using integrated human and robotic methods and advanced techniques, to inform design and development of exploration systems and enable safe operations. | 6 |
| **Lunar Infrastructure** | Create an interoperable global lunar utilization infrastructure where U.S. industry and international partners can maintain continuous robotic and human presence on the lunar surface for a robust lunar economy without NASA as the sole user, while accomplishing science objectives and testing for Mars. | 9 |
| **Mars Infrastructure** | Create essential infrastructure to support initial human Mars exploration campaign. | 4 |
| **Transportation and Habitation** | Develop and demonstrate an integrated system of systems to conduct a campaign of human exploration missions to the Moon and Mars, while living and working on the lunar and Martian surface, with safe return to Earth. | 12 |
| **Operations** | Conduct human missions on the surface and around the Moon followed by missions to Mars. Using a gradual build-up approach, these missions will demonstrate technologies and operations to live and work on a planetary surface other than Earth, with a safe return to Earth at the completion of the missions. | 12 |

Figure 2: The Moon to Mars Goals are described with associated number of objectives listed for each.

Along with the 63 objectives, NASA established nine Recurring Tenets, or common themes that apply to all objectives. The Recurring Tenets focus on crew safety, maximizing science, responsible use of outer space, interoperability, international and industry collaboration, and commerce.

# 3. WHO, WHAT, WHEN, WHERE, WHY, AND HOW?

The answers to these questions must reflect the highly interdependent effects each has on the other, but all must be addressed to arrive at a complete architecture approach. NASA's Moon to Mars strategy starts with *why*. The three pillars — science, inspiration, and national posture — form the basis for *why* we explore and prompt a decision-making process to address *what* capabilities are needed, *where* those capabilities should be developed, *how* to get there and back, *when* to do it, and *who* participates.

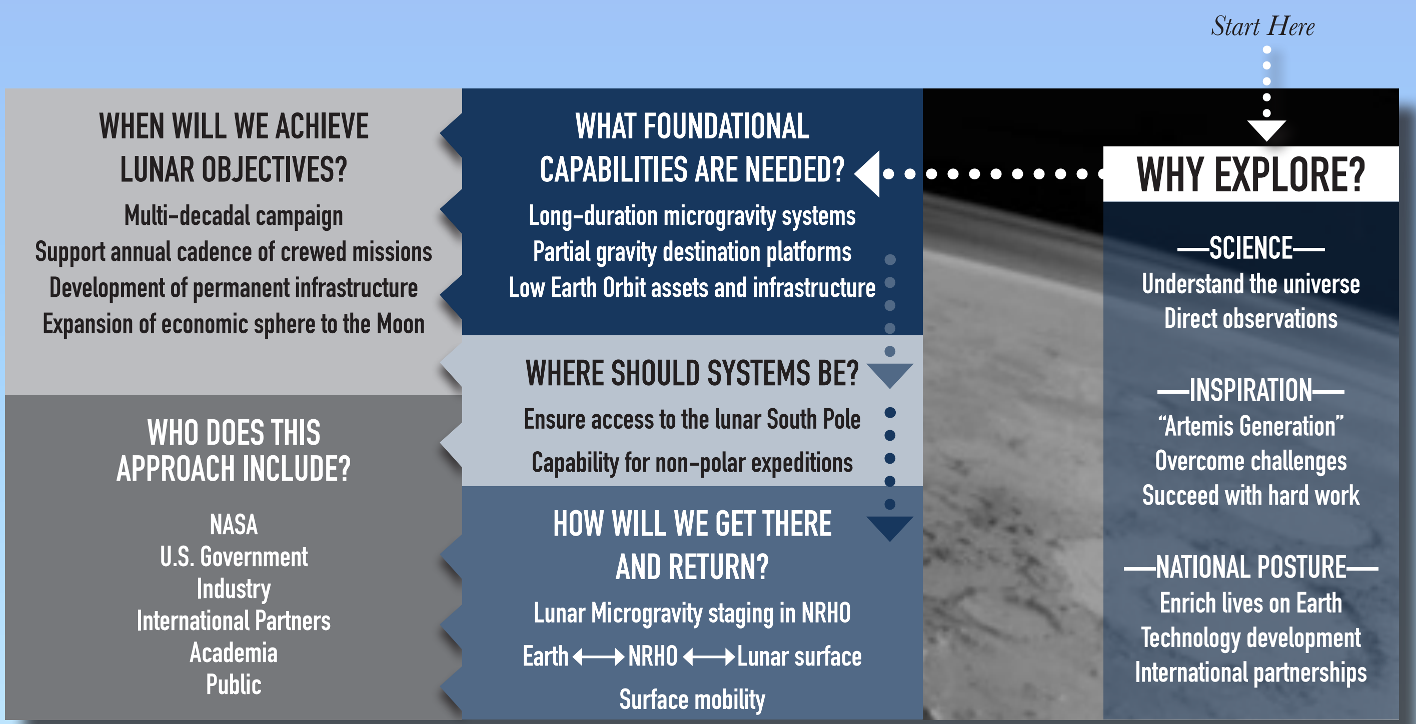



Figure 3: Lunar architecture decision flow starting with "why?"

Answering the *why* for exploration is only the first step in the decision process for human missions to the Moon and Mars. Answering, or exploring the options for other big architecture questions (*what, where, how, when, who*), helps define the key characteristics of the lunar exploration campaign.

## WHY

As established, the core benefits to humanity shown in Figure 1, while not exhaustive, shape the reasons for continuing the bold endeavor of human exploration across the solar system.

## WHAT

Long-duration platforms in lunar orbit and on the lunar surface will establish the foundational infrastructure to incrementally assemble and aggregate the systems needed to support a multi-decade campaign of scientific research and exploration at the Moon. The International Space Station already serves as a laboratory to validate advanced crew systems, technologies, and in-space assembly. Future lunar systems will expand this work.

## WHERE

The lunar south polar region is among the oldest parts of the Moon — older than any explored during Apollo — because it has not been covered by younger lava flows or other deposits. The volatiles there, likely trapped as ice, could reveal valuable knowledge about the history of the inner solar system, including when life gained a foothold on the Earth.

The lunar South Pole is an important engineering driver for long-duration platforms, with several features of interest to the architecture. Systems designed for the Delta-V, or changes in velocity, that vehicles must provide to reach the South Pole ensures access to other lunar areas. The South Pole also has enabling solar lighting factors to support long duration missions. This is a result of the Sun sitting continuously near or just below the horizon providing some precise locations with near continuous light. By designing systems for one of the most challenging locations on the Moon, opportunities for global scientific research and exploration are possible.

## HOW

Understanding that the lunar South Pole is the driving destination, and that periodic global access to the lunar surface may be needed, the next question is how to establish staging operations in lunar orbit.

NASA studied many lunar orbits and selected a near-rectilinear halo orbit. Landers departing this orbit can access the entire Moon, and it is gravitationally balanced between the Earth and Moon, requiring very little propellant for a spacecraft to operate in it for many years.

Transportation systems are developed early in the architecture, starting with the rocket and spacecraft that will carry astronauts from Earth to lunar orbit, and from lunar orbit to the lunar surface and back, which enables the objective satisfaction for initial access.

## WHEN

The lunar portion of the architecture is underway following successful completion of the Artemis I mission, selection of the Artemis II crew, and hardware and systems in development and production. When answering *when*, the focus is on frequency and shaping the architecture to support a steady cadence of crew missions and cargo deliveries to the Moon while continuing architectural analysis to further refine future Mars mission concepts.

The Moon to Mars architecture spans multiple decades to establish permanent footholds on and around the Moon before embarking on the first human missions to Mars.

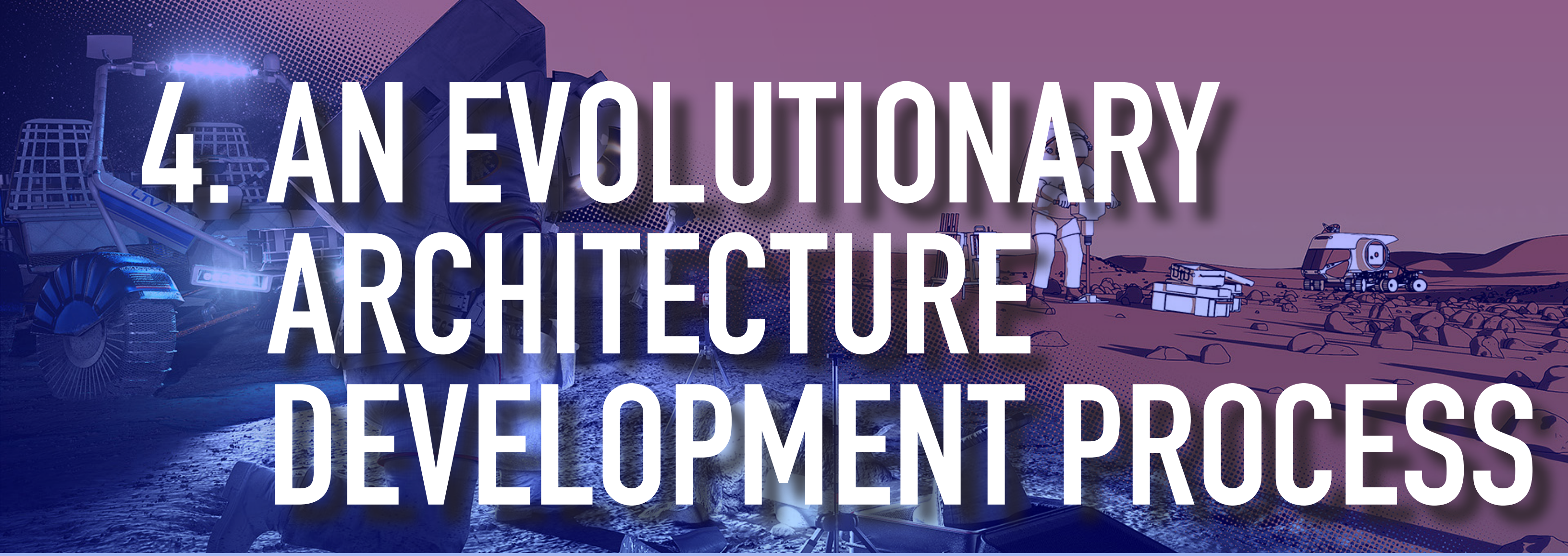
## WHO

The crew is the most critical component of any human mission. Vehicles, systems, training, and operations must be designed, developed, and certified to be safe and reliable for the "human system."

NASA will work with a diversity of partners including other U.S. government agencies, U.S. industry, academia, and international space agencies — and many of these partnerships are already in place. Through the International Space Station, NASA has worked to commercialize low-Earth orbit and expand access to space, creating new opportunities for commercial entities in low-Earth orbit and now beyond. In addition, continued engagement with international space agencies around the world will enable new, mutually beneficial opportunities for collaboration.

This expanded paradigm affects not only *who* goes to space, but also *who* finds lifelong careers in the growing global space economy.

# 4. AN EVOLUTIONARY ARCHITECTURE DEVELOPMENT PROCESS



NASA is evolving its approach to exploration planning by moving toward a process that begins with the globally developed Moon to Mars Objectives, and then applies a systems engineering method to distill those objectives into architectural components.

This process is referred to as “architecting from the right” because it begins with the broadest, long-term goals – farthest to the right on a timeline – and works backward to ensure that each goal is traced to the elements needed for success.

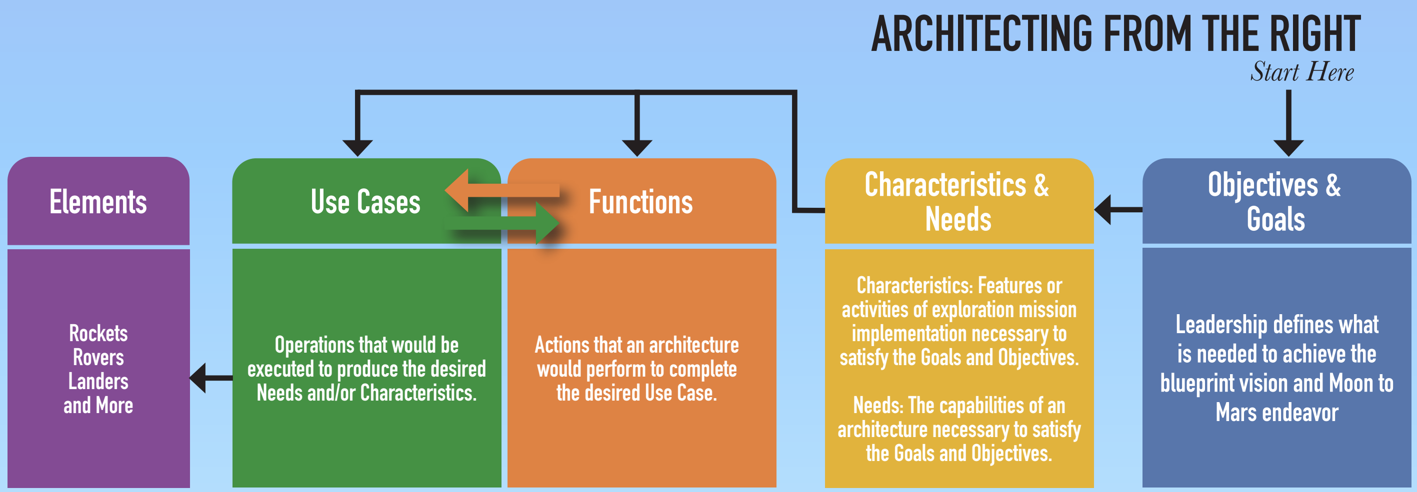



Figure 4: This diagram illustrates the process of architecting from the right, starting with globally developed Moon to Mars Objectives. The objectives are distilled into architectural components to arrive at the elements needed for success.

## ANNUAL ARCHITECTURE CONCEPT REVIEWS

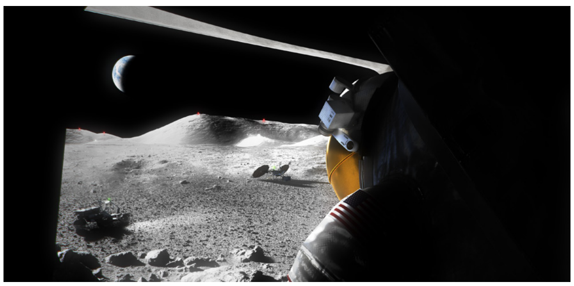
NASA conducts annual study cycles to work through the architecture distillation process. To formalize this process, these study cycles now culminate with agency-level Architecture Concept Reviews (ACRs). The focus of the first ACR, conducted in January and February 2023, was to gain concurrence on the evolutionary process and review the architectural analyses conducted in 2022. Future ACRs will be conducted annually in November to review the architecture studies completed in the prior fiscal year.

Although the ACR is an internal NASA activity, it provides an opportunity for the agency to share its architecture progress with current and future partners and enables opportunity for feedback and dialogue across all stakeholder groups. Throughout the year, NASA engages in conceptual and technical interchanges with private companies and space agencies across the globe and publishes papers at technical conferences to share intermediate progress.

To facilitate the incremental development and deployment of elements, the Moon to Mars architecture is organized into segments. Segments are defined as portions of the architecture, identified by one or more notional missions or integrated Use Cases, with progressively increasing operational complexity and objective satisfaction. These segments occur temporally, with increasing system and mission scope; however, deployment of elements may overlap segments in actual execution. The segmented approach allows NASA to break the architecture down into manageable pieces to focus and prioritize its analysis work and coordinate with partners. The architecture described in this document provides a higher level of detail for the near-term segments, with a structure for analysis to achieve a similar level of detail for future segments.

The architecture segments — *Human Lunar Return*, *Foundational Exploration*, *Sustained Lunar Evolution*, and *Humans to Mars* — are described below.

# ARCHITECTURE SEGMENTS



## HUMAN LUNAR RETURN

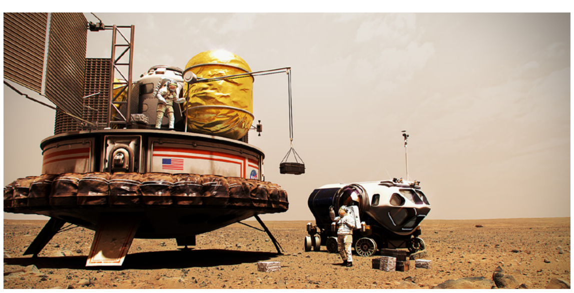
Initial capabilities, systems, and operations necessary to re-establish human presence and initial utilization (e.g., science) on and around the Moon.

## FOUNDATIONAL EXPLORATION

Expansion of lunar capabilities, systems, and operations supporting complex orbital and surface missions to conduct utilization (e.g., science) and Mars-forward precursor missions.

## SUSTAINED LUNAR EVOLUTION

Enabling capabilities, systems, and operations to support regional and global utilization (e.g., science), economic opportunity, and a steady cadence of human presence on and around the Moon.



## HUMANS TO MARS

Initial capabilities, systems, and operations necessary to establish human presence and initial utilization (e.g., science) on Mars and continued exploration.

# 5. HUMAN LUNAR RETURN

The *Human Lunar Return* segment establishes the deep space transportation systems for crew and cargo and the first Artemis moonwalks, beginning a new era of lunar scientific research. It includes a regular cadence of robotically delivered scientific instrumentation to the lunar surface, and the supporting communication systems to help inform and support missions in future segments.

*Human Lunar Return* is happening now, with several elements in operation and in development.

In 2022, the Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) CubeSat launched and entered Gateway's future orbit, a lunar near-rectilinear halo orbit. Also in 2022, NASA launched the Artemis I flight test, accomplishing all major flight test objectives and even adding new objectives mid-flight to further demonstrate Orion's capabilities ahead of Artemis II.

## DISTILLING OBJECTIVES TO ARRIVE AT ARCHITECTURAL ELEMENTS

The Moon to Mars Objectives described in Section 2 establish the framework for long-term scientific exploration at the Moon, Mars, and beyond. Because the goals and objectives very broad, NASA distills them down to the elements needed to achieve them.

The example in Figure 5 illustrates how the Transportation and Habitation objective ,TH-1, is broken down. This distillation begins from the architectural right to define the Characteristics & Needs necessary to accomplish the objective. These are then traced to the Use Cases and Functions that Elements must provide to accomplish the objective. The Elements are assigned to flight programs, projects, and systems.

To see a full decomposition of the Moon to Mars Objectives for *Human Lunar Return*, please see the Architecture Definition Document.

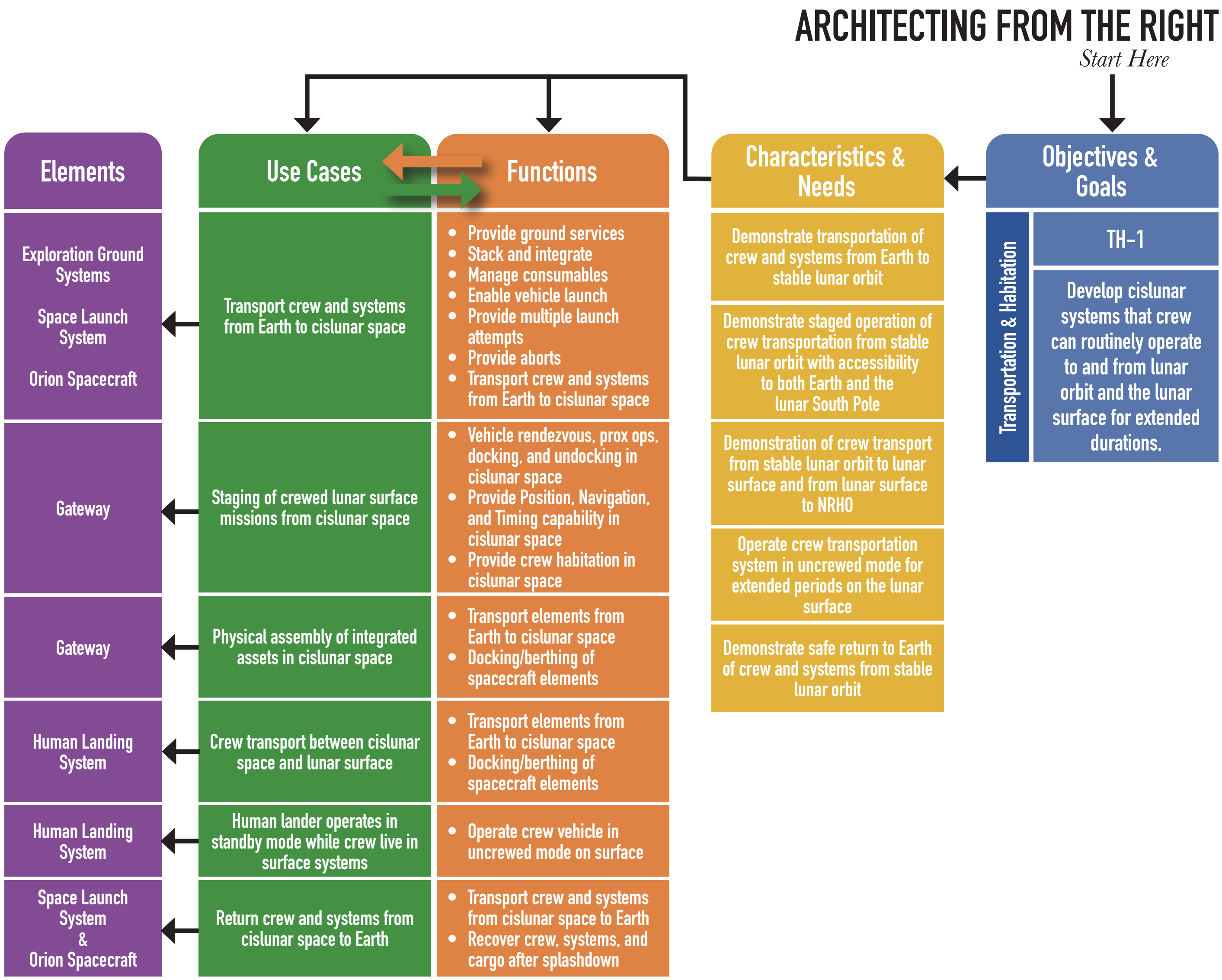



Figure 5: Example of the full distillation of the objectives into lunar-specific Use Cases, Functions, and Elements using one of 12 Transportation and Habitation Objectives.

## HUMAN LUNAR RETURN ELEMENTS

The following pages identify the *Human Lunar Return* elements that are traced to the Use Cases, Functions, Characteristics and Needs — all of which are distilled from the Moon to Mars objectives as illustrated in Figure 5.

The *Human Lunar Return* elements are the major systems necessary to establish the initial foothold in lunar orbit and on the surface. Initial missions will be used to establish early scientific operations in cislunar space and on the lunar surface, including the curation of samples to return to Earth. The segment is focused on demonstrating initial capabilities, systems, and operations necessary to re-establish human presence around and on the Moon. This segment began successfully with the Artemis I mission to systematically and progressively test areas such as crewed transportation to cislunar space, supporting ground infrastructure, and deep-space communications and tracking systems. The next steps are crewed transportation to and from cislunar space, initial Gateway deployment, rendezvous and docking, uncrewed Human Landing System demonstration, initial human landing, initial surface spacesuit and moonwalking capability, and uncrewed payload delivery. It encompasses the return of humans to the Moon for surface expeditions lasting about a week and establishes the foundational capabilities that will make future segments possible.

# HUMAN LUNAR RETURN ELEMENTS

## SPACE LAUNCH SYSTEM (SLS)

The SLS is an evolvable rocket that will provide heavy-lift capability to deliver Orion and its crew, supplies, and other payloads safely to the Moon. In 2022, NASA's Artemis I flight test successfully demonstrated the rocket's capability to send Orion on a lunar trajectory.

Future evolutions of SLS will feature a more powerful upper stage and larger payload volume to send large elements to the Moon, along with Orion and its crew.

## ORION SPACECRAFT

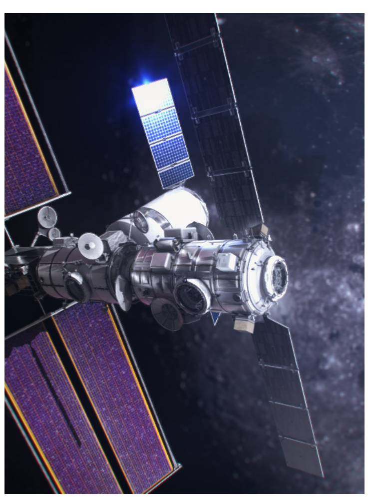
Orion transports up to four astronauts between Earth and lunar orbit and sustains them for up to 21 days. It also provides supplemental power and life-support systems to Gateway while docked to the lunar space station.

Orion launches from Earth atop the SLS, as it did in the Artemis I flight test, and includes the crew module, service module, and launch abort system.

## EXPLORATION GROUND SYSTEMS (EGS)

EGS provides the ground infrastructure to process and launch SLS and Orion, and also provides recovery capabilities when Orion returns to Earth. EGS uses the Vehicle Assembly Building (shown left) to stack and integrate SLS with its payloads, including Orion.

The Mobile Launcher is another key EGS capability that secures the SLS stack for transportation to Launch Pad 39B atop the crawler-transporter. The Mobile Launcher will be upgraded in future segments to accommodate the evolved SLS.



## GATEWAY

The Gateway includes several modules that are incrementally launched and assembled in lunar orbit. In the *Human Lunar Return* segment, the Power and Propulsion Element (PPE) and Habitation and Logistics Outpost (HALO) are launched together, along with three science instrument suites on a commercial rocket to the near-rectilinear halo orbit.

I-HAB, the International Habitat provided ESA (European Space Agency) and JAXA (Japan Aerospace Exploration Agency) then joins PPE and HALO for additional habitation volume. This segment also sees the first Gateway Logistics Module delivery with supplies to outfit the station. ESA, JAXA, and the Canadian Space Agency will all provide Gateway elements for later segments of the lunar architecture.

## DEEP SPACE LOGISTICS

Deep Space Logistics leads the commercial deep space supply chain to transport cargo, payloads, equipment, and consumables to enable exploration of the Moon and Mars. Logistics flights supply Gateway with critical cargo deliveries to maximize the length of crew stays aboard Gateway.

At least one logistics delivery is anticipated for each 30-day Artemis expedition aboard Gateway, and additional capabilities may be added in future segments. An illustration of a commercial logistics module is shown in the image to the left.

## HUMAN LANDING SYSTEM (HLS)

The Human Landing System (HLS) will transport astronauts and their cargo between lunar orbit and the surface. Crew will board the HLS either from Orion or from Gateway.

In this segment, HLS provides the habitable volume, consumables, and design features to allow crew to conduct moonwalks. Later segments will include additional cargo delivery options and habitation on the surface. A commercial provider has been selected for the Artemis III and Artemis IV missions (illustration shown, left). NASA will work with multiple providers to procure landers, and, eventually, landing services for Artemis V and beyond.

## xEVA SYSTEM

The Exploration Extravehicular Activity System (xEVA) includes the lunar surface spacesuit, tools, and vehicle interface equipment that crew will need to conduct moonwalks, collect samples, and deploy science instruments and technology demonstrations.

NASA has two spacesuit providers on contract who can bid to provide spacesuits as services to the International Space Station or to Artemis missions.

## COMM, POSITIONING, NAV, TIMING (CPNT)

Communication, Positioning, Navigation, and Timing (CPNT) services are provided through a combination of assets on Earth, in lunar orbit, and on the lunar surface. On Earth, upgrades to the Deep Space Network, and global installation of the Lunar Exploration Ground System, will provide continuous coverage of the Moon with support from systems in lunar orbit, including Gateway and the Lunar Communications Relay and Navigation System.

CPNT capabilities will grow throughout this segment and beyond, with opportunity for commercial and international partners to provide enhanced or augmented services.

## COMMERCIAL LUNAR PAYLOAD SERVICES (CLPS)

Through the CLPS initiative, NASA is acquiring services from a provider pool of U.S. companies to deliver payloads to the lunar surface.

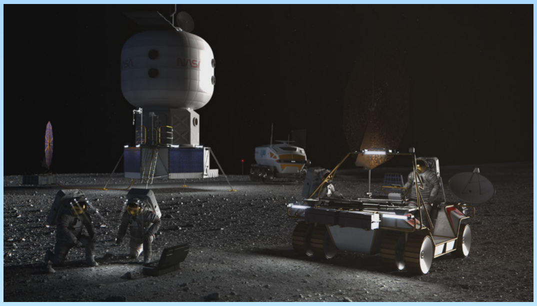
Although some equipment will be delivered to the surface with the crew aboard HLS, CLPS provides an additional capability to deliver cargo and science instruments with commercial providers, supporting a growing lunar economy. NASA's Science Mission Directorate currently has more than 40 U.S. and international science and technology payloads scheduled to be delivered through CLPS providers.

# 6. FORWARD WORK

The evolutionary architecture development process described in Section 4 is methodical and deliberate. NASA's intention is to foster transparency so that current and future partners can engage in productive discussions about future collaborations via available, open-source information and shared expectations and objectives.

To reach the required level of maturity for segments beyond *Human Lunar Return*, the process must continue. Through subsequent analysis cycles and annual Architecture Concept Reviews, the Moon to Mars architecture will grow more defined over time. Implementation of the architecture has already begun for the *Human Lunar Return*, with elements in that segment directly traced to Moon to Mars Objectives. Objectives distillation for *Foundational Exploration* and *Sustained Lunar Evolution* has also begun, as shown in Appendix A of the Architecture Definition Document.

The *Humans to Mars* segment studies center around early human missions to Mars to define key areas that will inform long-term investment strategies for the larger architectural components, many of which can find early or prototype development in the lunar segments. The ability to identify common systems and operations for both the Moon and Mars provides an additional level of confidence for the earliest human missions to the Red Planet. Decisions made about the *Humans to Mars* segment will be updated in future versions of the Architecture Definition Document.

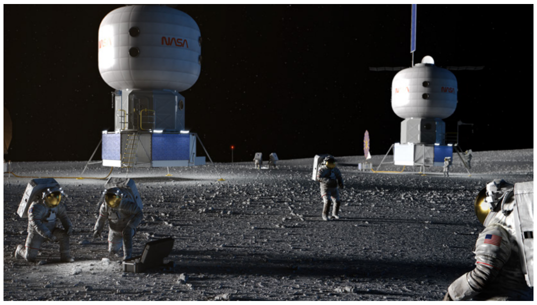


## FOUNDATIONAL EXPLORATION

The *Foundational Exploration* segment continues using capabilities established in *Human Lunar Return* and initiates new systems to expand mission durations and surface exploration range, increasing the diversity of scientific sampling and research and prepare for human missions to Mars.

Additions to Gateway and the delivery of habitation and mobility elements on the surface will introduce longer mission timelines, accommodating more opportunities to conduct an array science and demonstrate new technologies. The extended mission durations and co-located assets in orbit and on the surface will help optimize operations to conduct Mars mission simulations. *Foundational Exploration* also will be the starting point for activities and capabilities featured in the *Sustainable Lunar Evolution* segment.

NASA used the same process applied in *Human Lunar Return* to distill Moon to Mars Objectives for *Foundational Exploration*, but work remains to map the Functions and Use Cases to specific elements. The general functional capabilities under analysis now for the lunar surface include unpressurized mobility, pressurized mobility, surface habitation, and cargo transportation. In orbit, Gateway's capabilities will grow with contributions from international partners.



## SUSTAINED LUNAR EVOLUTION

In the *Sustained Lunar Evolution* segment, NASA aims to build, together with its partners, a future of economic opportunity, expanded scientific discovery, and greater participation on and around the Moon.

This "open canvas" segment embraces new ideas, systems, and partners to grow beyond *Foundational Exploration*, increasing global lunar science capability, making longer stays for more astronauts and researchers possible, and leading to the large-scale production of goods and services derived from lunar resources.

It is premature to determine specific elements for *Sustained Lunar Evolution* beyond the higher-level capabilities associated with the Moon to Mars Objectives. For this segment, the focus is on expanding power generation and storage; using lunar resources for propellant; crew consumables; construction materials; and expanding mobility and habitation to accommodate larger populations on the lunar surface.

## HUMANS TO MARS

Like the previous two segments, the Use Cases and Functions for *Humans to Mars* have not been fully distilled from the Moon to Mars Objectives to arrive at the specific elements needed for the first human missions to Mars.

To support ongoing analysis for *Humans to Mars*, NASA is studying a range of potential mission assumptions to inform system and technology concepts. To illustrate the range of potential Mars architecture solutions, some representative initial assumptions for the current body of analysis work include, at a minimum:

- A light initial exploration footprint: four crew members to Mars orbit with two crew members descending and living on the surface for a 30-sol surface stay;
- Multiple Mars landers, with the first lander(s) pre-deploying cargo to prepare for a later crew landing;
- Modest initial surface infrastructure: minimal surface power and communications infrastructure, but no surface habitat; and
- "All-up mission" approach: crew depart Earth with all the transit propellant they need for the round-trip journey, meaning no propellant will be harvested on Mars for the crew ascent vehicle for early missions.

These assumptions provide a framework for direct architecture comparisons, and all decisions will be made with evolution in mind. More complex mission scenarios will be addressed in subsequent analysis cycles, but the initial step is to define a practical approach to achieve the first human missions to Mars.

The primary Mars systems under study include the transportation system that will carry crew from an orbit in the Earth-Moon neighborhood and back; the entry, descent, landing, and ascent system that will land astronauts on the surface and return them to Martian orbit; the surface systems that will keep crew healthy and productive, allowing them to explore and conduct high-value science on the Red Planet; and the crew support systems that will provide the required logistics, food, and health care throughout their round-trip journey.

# 7. SUMMARY

The Moon to Mars architecture is on a steady path with a process that is repeatable and flexible. NASA is committed to documenting the progress and evolution through annual Architecture Concept Reviews and updates to the Architecture Definition Document.

Documenting the architecture and the process serves many purposes. Internally, it ensures that NASA — from the administrator to the sub-system-level engineers — can confidently work toward the same goals. Externally, it provides an entry point for discussion and invites collaboration with current and future game-changing partners around the globe as we seek to send humans to other worlds.

## ADDITIONAL READING

This document provides a snapshot of the Moon to Mars architecture development process. The following materials provide additional detail for readers seeking the finer points. All materials are located at **www.nasa.gov/MoonToMarsArchitecture** and will be maintained at that location.

**Documents**

Architecture Definition Document
Moon to Mars Objectives Summary
NASA's Moon to Mars Strategy and Objectives Development

**White Papers:**

Systems Analysis of Architecture Drivers
Why NRHO: The Artemis Orbit
Why Artemis will Focus on the Lunar South Polar Region
Gateway: The Cislunar Springboard for International and Sustainable Human Deep Space Exploration
Mars-Forward Capabilities to be Tested at the Moon
Mars Transportation

National Aeronautics and Space Administration


**Headquarters**
300 Hidden Figures Way SW
Washington, DC 20546
www.nasa.gov/centers/hq


**www.nasa.gov**


NP-2023-04-3119-HQ